was about $25,000. This storm last exhibited destructive violence at Calumet, Canadian County, where it appeared about 3.14 p. m. At this place the path was about one-half mile wide and the funnel was well defined. Three persons were killed and 4 injured. The damage is conservatively estimated at $100,000. After passing Calumet this storm apparently died out. The third storm was observed first at Rocky, Washita County, at 2 p. m. The storm traveled in a northeasterly direction with a well-defined funnel cloud, and the path of destruction was about one-half mile wide. About 50 houses were destroyed in the town and some stock was killed in the country. Two persons were injured but none was killed.

The fourth storm occurred at Elk City, Custer County, about 5.07 p. m. There were five funnel-shaped clouds, and the combined width of the paths was from 1 to 2 miles. Thirty-five buildings, 13 head of live stock, and many farm implements were destroyed. Two persons were killed and 7 injured in this locality.

The fifth storm appeared at Butler, Choctaw County, about 6.30 p. m., and moved in the anomalous direction from southeast to northwest. The funnel cloud was well defined and the path of destruction about 500 feet wide. One person was killed and 3 were injured. The property damage is estimated at $50,000 in that city and vicinity.

The sixth tornado made its appearance in the vicinity of Hobart, Kiowa County, about 8.30 p. m., reached Sentinel, Washita County, about 9 p. m., and here exhibited two funnel clouds.

The seventh tornado occurred in the vicinity of Sentinel about 1.30 a. m. of the 28th. The path was not well defined, the funnel cloud apparently dipping down and destroying a building and then lifting over several and again descending. About 60 houses were blown down, and 2 persons were killed and 2 injured. It is impossible to estimate the loss in money terms, but it was great.

Tornadoes in Kansas, April 20, 1912.—Tornadoes occurred in south-central Kansas April 20, 1912. There were three storms. The first appeared at Bison, Rush County, at 3 p. m., moving from the south-southwest to north-northeast, and there was a funnel-shaped cloud. The path of greatest destruction was about 80 yards wide. Two persons were killed and about 15 injured. The damage to property amounted to about $70,000. The second tornado made its appearance near Nashville, Kingman County, about 3.30 p. m., moving from the southwest toward the northeast and passed near Willowdale, Kingman County, about 4 p. m. The funnel-shaped cloud was visible at both places. In the vicinity of Nashville the path of greatest destruction was 250 yards wide. Two persons were injured, a few head of live stock were killed, and about 10 houses and barns were blown down. In the vicinity of Willowdale the path of greatest destruction was about 150 feet wide. Two persons were injured, and buildings worth $8,000 were destroyed. The third tornado appeared 3 miles west of Waldron, Harper County, at 4 p. m., moving from the south toward the north. The path of greatest destruction was about one-fourth mile wide. One person was killed and 8 were injured. The damage to buildings and the loss of live stock amounted to about $10,000.

CITY AND SUBURBAN TEMPERATURES.

By EDWARD D. COBERLY, Local Forecaster.

Much has been written on this subject during the last few years, and some investigators have gone so far as to assert that only temperatures reduced to what they would be if taken in the open country should be used in the construction of general isothermal charts. There can be no doubt that in the cities, where instruments are exposed on the tops of large office buildings, the temperature records are more or less affected, particularly so when the atmosphere is sluggish and winds light. The large brick and steel buildings undoubtedly absorb great quantities of heat during the day in the bright sunshine and radiate the same at night. In winter the innumerable fires must give off an appreciable amount of heat, the effects of which are shown in our temperature records. The large quantities of dust and smoke particles in the atmosphere of our cities also exercise a great influence on radiation. Moreover, as these records are usually made at heights varying from 75 to 300 feet above the ground, the nocturnal cooling of the air near the surface of the earth is not shown by them.

A brief summary of some of the results of other investigations in this field seems to be pertinent in this connection, and the following short quotations from Hann's Climatology (Ward), pages 29–30, are given:

> As a general rule, it is found that the mean annual temperature of the air in places where there are many buildings is from 0.9° to 1.8° too high. The differences are greatest in the morning and evening and least at noon. The diurnal range of temperature is smaller in cities, especially in summer.
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> The mean temperature which is usually given for Paris is 1.4° too high; and this is likewise true for Brussels, London, and other cities. The mean temperature of the city of Vienna is 49.5°, that of the surrounding country 48.6°. Hellman also took into consideration the differences in the exposure of the thermometers, and found that Berlin is 0.5° warmer than the surrounding country in winter; 1.1° warmer in spring and summer; and 0.7° warmer in autumn. The evening temperatures in Berlin, however, are 2.2° higher in spring and summer, and 1.4° higher in the mean annual.
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> In the case of Paris there was found to be a difference of +4.2° on summer nights; the temperatures are the same at noon, and the difference is +2° in the diurnal and the annual means. The city is warmer than the country by these amounts. The mean mimima are much higher in the cities, while the mean maxima may be the same as those of the country, or sometimes even lower. The cooling by radiation at night is much greater in the open than in places which are built up. Mendenhall states that during the cold waves of January, 1884, the mean minimum temperatures registered at the regular Weather Bureau stations in Toledo, Cleveland, Columbus, and Cincinnati, Ohio, were from 3.1° to 14.9° higher than those recorded at cooperative stations outside the large cities.

Prof. J. Warren Smith finds that the mean maximum temperature for the year is 0.3° higher and the mean minimum 3.3° lower at Ohio State University (a country exposure) than at the regular Weather Bureau office in the heart of the city at Columbus, Ohio. He states that the minimum temperatures are considerably lower at the university than in the city.

At New Orleans records have been kept for the last 23 years at the Louisiana Sugar Experiment Station in Audubon Park, and we shall compare these records with those of the regular Weather Bureau station in this city covering a simultaneous period. During this time all records at the regular Weather Bureau station have been made on the roof of the customhouse, about one-fourth mile from the Mississippi River and 90 feet above the street level; this station will be designated "New Orleans No. 1" in our discussion. "New Orleans No. 2," or Audubon Park, is 6 miles west of the regular Weather Bureau office and about 800 feet from the Mississippi River. The instruments are exposed in a standard shelter, 6 feet over sod, and the location is ideal, being removed from buildings and paved streets, so that the exposure may be taken as almost perfect.

It is found that the mean annual temperature is 0.6° higher at the customhouse than at the park. The monthly mean temperature is higher at station No. 1 every month, except June and July, when the excess of the mean at the park is 0.2° and 0.3°, respectively.

The greatest excess in the monthly mean at the customhouse station, 1.5°, occurs in October. The mean maximum temperature at the park is higher in every month of the year, the excess ranging from 0.2° in November to 2.1° in June and 2.0° in July, and the annual mean maximum is 1.3° higher at the park than at the regular Weather Bureau station. Just the reverse of the case just stated is found for the minimum temperatures, those at the park being lower, and the difference between the two stations is about twice as great as in the case of the maximum temperatures. The annual mean minimum at the park is 2.6° lower than at the customhouse. The difference is least in midsummer and greatest in the autumn months, October and November, being 4.2° and 3.6°, respectively. It is the opinion of the writer that this is largely due to the generally light wind movement during the nocturnal hours at this season of the year, thus allowing the air to lie quietly over the grassy stretch of the park and cool rapidly by conduction to the cold ground which has radiated its heat much faster than the buildings in the heart of the city. This is very clearly shown by the light fog which hangs over the park at the time of lowest temperature, about sunrise nearly every morning, during the autumn months, while none is visible over paved streets less than half a mile away. It will also be noted that the maximum temperatures are usually 1° to 3° higher and the minimum readings 1° to 6° lower in the open exposure than on the top of the buildings. This difference in the case of minimum temperatures is very important in its bearing on the formation of frosts, and the occurrence of frost temperatures. If conditions are favorable for the occurrence of frost or frost temperature—that is, clear skies and light winds with the necessary fall in temperature—this inevitable difference between the temperature in the city and country should always be borne strictly in mind, as in critical times the difference of even a few degrees may mean the saving or losing of an entire crop.

These differences in minimum temperatures, especially, are much accentuated when the distance between country and city stations is increased somewhat and the country station is entirely removed from the city. After all, these differences are dependent solely on the causes which control nocturnal terrestrial radiation. Some striking examples have come to notice. Dr. I. M. Cline says:

> The temperature varies greatly in different localities in adjacent neighborhoods. The temperature at regular Weather Bureau stations is often very different from that which prevails in the neighboring agricultural communities. In this connection, Mr. H. Meyer, under date of Bertrandville, La., November 23, 1901, says: "There is considerable trucking done here in the early spring, and I hope you will give us warning when a cold wave comes along. What I can not understand is that the 16th of this month your record at New Orleans was 44° while at this place, 25 miles farther south, we had 32°. Ice formed as thick as window glass."

A comparison of the minimum temperatures recorded at the United States Weather Bureau office, St. Louis, Mo., with those recorded at the Forest Park Observatory shows that the mean monthly minimum at Forest Park was 1.5° to 9° below the mean monthly minimum at the Weather Bureau station. In the discussion of this matter the writers say:

> In the study of these observations it was found that during the clear skies of September the maximum differences were recorded, while during the cloudiest months (March and December) the differences were least, and that they remained small during all of the winter months. There were, however, marked exceptions to this rule, as, for instance, in January, 1892, when the difference exceeded 20° on three successive dates.

There also seems to be a marked control over radiation exercised by the color of the soil and whether or not the same be covered by vegetation. Differences of 10° or more, have been observed on adjacent plats of ground due to this cause.

A condensed table showing temperature conditions at the regular Weather Bureau station, New Orleans, La., and at the sugar experiment station, Audubon Park, this city, is appended.

A short bibliography of works which have been consulted in the preparation of this paper, which may be of service to those who desire to go more thoroughly into this subject of city and country temperatures and the control of nocturnal radiation by local causes, is given below.

Months.	Mean temperature No. 1.	Mean temperature No. 2.	Algebraic excess of No. 1.	Mean maximum temperature No. 1	Mean maximum temperature No. 2.	Algebraic excess of No. 1.	Mean minimum temperature No. 1.
January	54.7	53.5	+1.2	62.3	63.0	−0.7	46.6
February	56.0	55.3	+0.7	62.8	63.8	−1.0	47.2
March	63.7	62.9	+0.8	72.5	73.5	−1.0	56.5
April	69.0	68.4	+0.6	76.8	78.7	−1.9	60.9
May	75.2	75.0	+0.2	83.4	85.3	−1.9	67.7
June	80.5	80.7	−0.2	88.2	90.3	−2.1	73.2
July	81.9	82.3	−0.4	88.9	90.9	−2.0	74.9
August	82.2	81.9	+0.3	89.6	90.7	−1.1	75.4
September	79.3	78.4	+0.9	86.6	87.4	−0.8	72.9
October	70.5	69.0	+1.5	77.9	79.0	−1.1	63.4
November	62.0	60.7	+1.3	70.5	70.7	−0.2	54.5
December	55.3	54.6	+0.7	62.5	63.7	−1.2	47.1
Year	69.2	68.6	+0.6	76.8	78.1	−1.3	61.7

Months.	Mean minimum temperature No. 2.	Algebraic excess of No. 1.	Monthly maximum No. 1.	Monthly maximum No. 2.	Algebraic excess of No. 1.	Monthly minimum No. 1.	Monthly minimum No. 2.	Algebraic excess of No. 1.
January	43.8	+2.8	81	83	−2	22	21	+1
February	44.8	+2.4	82	84	−2	7	6	+1
March	54.1	+2.4	86	89	−3	31	30	+1
April	58.6	+2.3	89	90	−1	41	40	+1
May	64.2	+3.5	96	99	−3	52	46	+6
June	71.5	+1.7	98	100	−2	60	58	+2
July	73.5	+1.4	102	101	+1	63	65	−2
August	73.9	+1.5	100	100	0	68	65	+3
September	70.1	+2.8	96	98	−2	55	52	+3
October	59.2	+4.2	94	96	−2	40	35	+5
November	50.9	+3.6	89	90	−1	29	28	+1
December	44.2	+2.9	83	82	+1	21	19	+2
Year	59.1	+2.6	102	102	0	7	6	+1

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